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FROM THE

UNITED STATES GOVERNMENT

# PRINCIPLES OF

# WAR SURGERY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

# Principles of War Surgery

BASED ON THE CONCLUSIONS ADOPTED AT THE VARIOUS INTERALLIED SURGICAL CONFERENCES

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Prepared in the Office of the Surgeon General
Washington

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# TABLE OF CONTENTS.


Page.

Preface..... 5

CONCLUSIONS OF THE FIRST AND SECOND SESSIONS.

I. General principles in the treatment of war injuries, especially with regard to the prophylaxis of infection and to the sterilization of wounds..... 7
II. Study of laboratory methods for the purpose of aiding the surgeon in the choice of treatment..... 9
III. Comparative study of the different methods of extracting projectiles..... 11
IV. Gas gangrene; its pathological and bacteriological aspects..... 12
V. Treatment of gas gangrene..... 14
VI. Traumatic shock..... 16
VII. Amputations..... 19
VIII. Artificial limbs..... 24
IX. Fractures..... 26
X. Wounds of the blood vessels..... 34
XI. Wounds of the nerves..... 37
XII. Wounds of the spinal cord..... 39
XIII. Cerebral wounds..... 40
XIV. Wounds penetrating the chest..... 43
XV. Abdominal wounds..... 46

CONCLUSIONS OF THE THIRD SESSION.


| | | Page. |
|---|---|---|
| I. | Disinfection of wounds | 47 |
| II. | The value of bacteriology in war surgery | 48 |
| III. | Gas gangrene; treatment | 48 |
| IV. | Shock | 49 |
| V. | Artificial limbs | 50 |
| VI. | Surgical treatment of war fractures | 51 |
| VII. | Chest wounds | 56 |
| VIII. | Wounds of the abdomen and thorax | 57 |
| IX. | Brain wounds | 58 |
| X. | Treatment of nerve wounds | 61 |


CONCLUSIONS OF THE FOURTH SESSION.


| | | |
|---|---|---|
| I. | Wounds of joints; modifications to conclusions adopted at previous sessions | 63 |
| II. | Transfusion of blood | 63 |
| III. | Trench foot | 65 |
| IV. | Treatment of wounds of the pelvis, particularly those of the bladder and rectum | 68 |
| V. | The results of conservative operations for projectile wounds of the foot | 70 |
| VI. | Internal splinting in war fractures (pseudarthroses excepted) | 73 |
| VII. | Treatment of pseudarthroses (nonunion) | 75 |

# PREFACE.

Realizing the importance of the conclusions adopted by the Interallied Surgical Conferences, the Division of Surgery, authorized by the Surgeon General, has collected the conclusions of the four conferences into this pamphlet, in order to effect a widespread knowledge of the work of the conferences among the medical officers of the United States Army.

The conferences were held at Val-de-Grace, March 15, 1916, 1917; May 14–19, 1917; November 5–8, 1917; March 11–16, 1918. The reason for their existence was suggested by the following letter from Mr. Lloyd-George to Gen. Roques, the Minister of War for France:

I wish to draw your attention to a subject which, without doubt, you will agree is of interest and importance. It is a subject which has arrested the attention of the entire medical world and has excited a lively discussion.

The methods adopted by the allies for the treatment of wounds are not always identical and are not, perhaps, in agreement with those principles which might be regarded authoritative as well as fundamental. One thing is certain, the experience of the British Army has shown a great difference of opin-

ion between the surgeons and the bacteriologists, even among those who are quite competent.

There is no doubt that scientific researches of great importance have been achieved by the allied armies, and yet the results of the labor of eminent surgeons are not rapidly spread to the attention of thousands of medical officers actually serving in the hospitals and at the front.

I believe that the application of science by eminent practitioners should result, after two years of war, in a specific designation of those measures which should be approved and of those which, on the contrary, should not be authorized.

It would appear necessary to establish a liason on this subject for the general instruction of that large group of medical men who are charged with the treatment of the allied wounded.

I would therefore propose that, with that end in view, a conference be called in Paris between the surgeons and the bacteriologists to establish an agreement about these debated matters. It is not to be doubted that the members of such a conference, even if they differ among themselves on points of secondary technic, will nevertheless reach conclusions upon principles of fundamental importance.

The original papers and the discussions following them may be found in the Comptes-Rendus de la Conference Chirurgicale Interallée pour l'etude des plaies de guerre (Paris, 1917, 1918, L. Fournier, Ed.)

# PRINCIPLES OF WAR SURGERY.

## Conclusions Adopted by the Interallied Surgical Conference (England, Belgium, France, Italy, Japan, Portugal and Serbia[1]) Relative to the Treatment of War Wounds.

### FIRST AND SECOND SESSIONS, MARCH, 1917. AND MAY. 1917.

### I. General Principles in the Treatment of War Injuries, Especially With Regard to the Prophylaxis of Infection and to the Sterilization of Wounds.

1. The organization of the services should permit of the continuity of surgical direction in the treatment of the wounded.

2. At the battle posts, and especially in the trenches, surgical aid ought to be reduced to a minimum. It should be confined to warding off complications which

[1] The delegates from the United States and Russia could not attend the first two sessions.

might prove immediately fatal and to the protection of wounds from infection. The wound should not be explored or washed; it should simply be covered with a dry dressing, either aseptic or antiseptic.

3. The wounded should be transferred as quickly as possible to one of the large hospitals situated along the front at a distance of from 10 to 20 kilometers from the lines.

4. It is well for each of these hospitals to have one or more annexes nearer to the firing line to receive as early as possible the more serious cases (shock, serious hemorrhage, wounds of the thorax or abdomen, etc.).

5. In general, war wounds should be considered as contaminated or infected.

6. The ends to be attained by treatment are:

(*a*) Prevention of infection if the wound is only contaminated, or sterilization if infection has set in.

(*b*) The possibility of suture when clinical sterilization has been effected.

7. Wide opening of the wound and resection of the injured tissues and removal of bits of clothing or other foreign bodies should be regarded as a regular practice, except in benign cases which may be closely watched.

8. After such treatment immediate suture may lead to good results, especially in wounds of the joints. It should be performed only for recent wounds (at most

not over 8 hours old) and when the surgeon can watch the patient for a period of 15 days.[1]

9. If immediate suture has not been performed, recourse may be had to secondary suture as soon as sterilization of the wound has been clinically recognized to be sufficient.

10. The progress of the wound ought to be systematically controlled by successive bacteriological tests in series, so as to ascertain the bacterial curve and the degree of sterilization.

11. In the case of hurried removal of patients whose wounds have been opened and excised, it is well to apply a dressing the action of which would continue during the period of transportation. There is room for investigation along this line.

12. There are several methods of progressive sterilization of wounds which allow regularly of secondary suture.

## II. Study of Laboratory Methods for the Purpose of Aiding the Surgeon in the Choice of Treatment.

1. In every important surgical service there should be an experienced bacteriologist with sufficient competent assistants and a laboratory adequately equipped.

[1] Compare this with the conclusion expressed at the third conference, p. 47.

2. The treatment of war wounds calls for close cooperation of surgeon and bacteriologist. The bacteriologist should himself come in direct contact with the wounded and should study and consult with the surgeon as to the investigations to be made and the treatment to be applied.

3. In general, the investigations should be bacteriological, cytological, and humoral.

4. There is no reason to confine investigations within narrow limits, so far as indications are concerned, however, the principal problems for research appear to be the following:

(*a*) The bacteriological flora of the wound at the start.

(*b*) The bacteriological flora of the wound before and after surgical treatment, or before and after any considerable transfer of the patient.

(*c*) The bacteriological flora of wounds which continue to suppurate or which present a complication.

(*d*) Bacteriological control followed by sterilization of the wounds with a view to suture.

(*e*) Bacteriological and biological control of the wounds for the purpose of determining the efficacy of various methods of treatment.

(*f*) Examination of the blood for bacteria, the number of formed elements, and defensive properties; also possible indications for the transfusion of the blood.

(*g*) Special infections of certain anatomic regions, such as articulations, serous membranes, mucous membranes, muscles, brain tissue, and cerebrospinal fluid. Bacteriological, cytological, and humoral studies should be made along these lines.

(*h*) The general indication for, and the application of, vaccine therapy.

5. In addition to laboratories attached to the services for the purpose of practical surgical assistance, more laboratories should be established for scientific research along general lines with regard to war surgery, and those already in operation should be adapted and organized more specifically for this purpose.

## III. Comparative Study of the Different Methods of Extracting Projectiles.

1. A thorough radiological examination should be made of each case as soon as general conditions permit.

2. The extraction of projectiles ought not to be attempted without some method of localization.

3. In the surgical services at the front, especially at times of great activity, radioscopic methods are most desirable.

4. The surgeon should without fail have at his disposal during an operation some one of the numerous apparati of direction and control (radiograph, stereo

scope, electrovibrator, compass, finger-stall telephone, or intermittent controller of rays).

5. In fixed services during periods of moderate activity, radiographic methods are sufficiently indicated.

6. The conference calls especial attention to the necessity of providing every radiographic apparatus with all possible means of protecting the surgeon and radio operator from the X rays.

## IV. Gas Gangrene: Its Pathological and Bacteriological Aspects.

A. *Pathological.*—Under this heading will be considered the so-called "favorable" conditions.

At present, especially from a surgical point of view, predisposing conditions play the most important rôle, because at least some of them are amenable to therapeutic treatment.

Predisposing causes may be classed as general and individual.

(*a*) *Predisposing causes of a general order.*—1. Geographic variations: The frequency and the clincal type of gas gangrene seem in a measure to be influenced by geographical environment.

2. Wounds from artillery projectiles or grenade explosions are the most dangerous.

(*b*) *Predisposing causes of an individual order.*—Certain characteristics are almost constantly found in

wounds which tend toward gangrene; the most important are:

1. The situation of a wound in the fleshy parts of a limb, especially of a lower limb.

2. The special character of a wound, such as a narrow orifice with deep and important lesions.

3. The presence of foreign bodies, and especially of bits of clothing, which may have on them earth with its infectious or fecal matter.

4. Extended contusion of the tissues, with partial devitalization. Other predisposing conditions, less constant but frequent, are:

5. Great destruction of the bone or of an articulation.

6. Ischemia resulting from vascular lesions, from ligatures, and from a prolonged application of a tourniquet.

7. Multiplicity of wounds.

8. Hematoma.

9. Genuine traumatic shock.

10. Chances of gangrene are reduced according to the promptness of adequate surgical treatment.

11. Even after the proper treatment gas gangrene may result from the too hasty removal of a patient or from an insufficient method of treatment, especially after the application of dressings which permit the desiccation of wounds.

12. Attention is especially called to certain causes of intoxication in gas gangrene, and more particularly to acidosis, whether general or local. Therapeutic indications may result.

B. *Bacteriological.*—1. Investigations carried on from the beginning of the war have confirmed the infectious origin of gas gangrene and the anaerobic character of the bacteria which provoke it.

2. Among the bacteria encountered are to be noted the vibrion septic (Bacillus of malignant œdema), the Bacillus bellonensis (the precise relationship between the Bacillus bellonensis and the Bacillus œdematiens is still undetermined), and the Bacillus perfringens (aerogenes capsulatus).

3. Infection is often aggravated by the presence of additional bacteria, especially the streptococcus.

4. There is much need of research for the purpose of obtaining active serums against the above-mentioned bacteria.

Such sera have been prepared, and their activity on animals has been proved.

## V. Treatment of Gas Gangrene.

1. Gas gangrene is very often the result of delayed or insufficient surgical treatment.

2. Prophylactic treatment is most important. This necessitates the early removal of the wounded to surgi-

cal centers, where they may receive adequate care, complete opening of the wounds, excision of devitalized or gangrenous tissues, removal of all foreign substances, and careful hemostasis.

3. In the localized varieties with or without infiltration curative treatment consists in:

(*a*) Complete exposure to the air of deep pockets.

(*b*) The excision of all gangrenous or suspected tissues.

(*c*) The practice of lengthy incision into the region of infiltration and to the limits of this region.

4. Amputation is imperative in the case of massive gangrene, especially if it is complicated with bony or serious vascular lesions, and of gangrene of a rapidly spreading variety, accompanied by a generally alarming condition. (A quick fall in blood pressure is, in this connection, an important symptom.) The operation generally chosen is a flapless amputation.

When the amputation is to be made in healthy tissue our English colleagues recommend an operation employing short flaps held apart. When the amputation is to be made in an infiltrated region it is best to open wide the infiltrated part of the stump by incisions reaching to the upper limit of the member or to the trunk.[1]

[1] MM. Depage and Derache add that interstitial injections of oxygen, superficial or deep, made above and below the wound as far as the distention of the skin, is a valuable adjuvant in surgical treatment.

5. Anesthesia by means of nitrous oxide with oxygen is considered the best, when this is not to be had, ether may be substituted.

6. When projectiles are to be extracted or secondary and late operations are to be performed it must be remembered that the process may give rise to gangrene.

## VI. Traumatic shock.[1]

Traumatic shock is a disturbance in the functional equilibrium, characterized clinically by reactions of a depressive nature which may result in death. The essential phenomena are cooling of the body and low blood pressure.

It is often accompanied by serious hemorrhages or acute toxemia which make it especially difficult to diagnose.

It may be caused or aggravated by pain, cold, and fatigue.

Diastolic blood pressure continuing at less than 60 mm. (Pachon), independent of hemorrhage or toxemia, is an indication for treatment to be applied *manometer in hand.*

This treatment may be summarized as follows:

(*a*) *At regimental posts and divisional rescue stations.*—1. Injection of stimulants, especially camphor

[1] Compare with conclusions adopted by Third Conference p. 49.

ated oil (dose 10 c. c.) repeated every two hours, is often the only treatment upon which the surgeon may rely.

2. The wounded should be removed when possible in heated ambulances.

(*b*) *At advanced services or hospitals at the front.*—The posture given to the wounded, the heating of the body, and the reestablishment of normal blood pressure, constitute the three essentials in any treatment.

1. The patient should be placed in a horizontal position or one slightly inclined. This position is always to be avoided in wounds of the chest or of the brain. A compressive rolled bandage may be applied to the limbs.

2. The surface of the body should be kept carefully in an atmosphere heated to about 40° C. The restoration of body heat is an important indication in the treatment.

3. Absolute repose is imperative. Every useless movement and every cause of pain and excitement must be avoided.

4. Enteroclysis (drop method) of an isotonic solution with 1 per cent alcohol added, is advisable.

5. An attempt should be made by means of intravenous injections of saline solutions to reestablish the

blood pressure. These injections may be made in large or small repeated doses.

Small repeated doses (250 c. c. maximum) are preferable in genuine cases of shock without an important loss of blood. The effect upon the blood pressure is more lasting when the injection is made at the end of the operation. Later injections should be administered in accordance with the curve for the blood pressure, which should be determined by half-hourly observations. A new injection should be made every time the curve assumes an unfavorable bend.[1]

6. Is shock an indication or a counterindication for operation?

---

[1]As an isotonic solution to be injected the Locke solution is preferable.

| | gm. | | gm. |
|---|---|---|---|
| Chloride of sodium | 8.0 | Chloride of calcium | 0.1 |
| Chloride of potassium | 0.2 | Glucose | 1 |
| Bicarbonate of soda | 0.2 | Water | 1,000 |

The injection should be made slowly, lasting about 10 minutes. If a second injection is necessary, a solution with a larger proportion of calcium than Locke's solution (hypertonic solution) may be employed.

If the blood pressure falls a great deal, a third injection should contain adrenalin (added at the time of using). Just as the injection s to be made the following ingredients may be mixed: 0.5 c. c. of the olution 1 to 1,000 adrenalin; and 50 c. c. of isotonic solution of the irst formula. The injection should always be made slowly, never in less than 10 minutes. Only completely colorless adrenalin should be used. The action of the adrenalin and of the pituitary extract is short lived. The transfusion of blood seems also to give results as in the case of hemorrhage.

The answer to this question depends upon the seriousness of the shock and the nature of the operation.

If the shock itself—aside from the hemorrhage—is serious, if the patient is cold and without a pulse, the shock must be treated first. The same is true if the operation to be performed is long or complex, as in the case of abdominal operations. Any considerable injury to the members calling for amputation is, nevertheless, an indication for operation.

Local anesthesia combined with general anesthesia by means of nitrous oxide is the best. Next to this ether appears to be the least harmful. Spinal injections have produced varying results according to the surgeons employing them, especially in amputations of the lower limbs. The use of chloroform is dangerous.

7. A condition of shock calls for the quickest possible process of operation—the simpler the better—with complete hemostasis (preventive, temporary, and permanent).[1]

## VII. Amputations.

1. Amputation is desirable only when the preservation of the limb would result in death or when its loss is certain.

2. The two chief indications for amputation are extensive traumatism and infections.

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[1] Compare with conclusions of the third session, p. 50.

3. Amputations for complicating infections are always very serious. Statistics based upon 29,139 amputations show a mortality of 28 per cent in cases of infection against the usual mortality of 6 per cent. Statistics drawn from 3,633 disarticulations lead to the same conclusions.

4. Amputation is called for less frequently in injuries to the upper limbs than is the case with the lower limbs. Less serious and less frequent infection, the favorable results of resection, and the unsatisfactory nature of substitutes for the upper limbs are the chief reasons for this difference.

5. Indication for primary amputation is extensive traumatism; such as laceration, crushing, and incomplete separation of the limb, especially if there is a rupture of the great veins and arteries.

6. An indication for secondary amputation is dry or seriously infectious gangrene. Other ascending infections (superficial gangrene) are amenable to conservative treatment.

7. Late amputations are indicated in chronic infections by cachexia, which is not amenable to treatment.

Primary amputations, or that within 24 to 48 hours, should be effected as nearly in the region of the fracture as the seriousness of the lesions will permit. The operation should be by simple section of the soft parts or with rectification of the bones.

Amputation for infection should be flapless or with short flaps held apart. If there is need it can be revised when the wound has been disinfected and the soft parts have been given all the elongation possible.

The technique of a delayed amputation should be determined largely by the requirements of an artificial limb.

In cases of fracture complicated by extended fissures of the bone, amputation may be performed in the region of the wound, thus preserving the fissured bone, provided sufficient disinfection of the wound is possible.

1. In the case of serious shock the use of nitrous oxide and oxygen is desirable; ether is the next best anesthetic.

2. In general, except in extreme cases, shock is not a counterindication for amputation.

3. Preventive hemostasis is necessary; it should be complete.

4. The periostium should be neatly cut without causing separation.

5. In primary amputations, especially for infection, the wound ought to be left wide open. The operator should be on his guard against interstitial separations. English surgeons even advise leaving the blood vessels ligatured and the nerves exposed at the surface of the wound.

6. After the operation, the chief precautions should be: 1. The disinfection of the wound against osteomyelitis; 2. The control of the healing of the flaps.

7. More attention should be paid to the length of the stump than to the amount of remaining flesh.

*Amputations of the lower limbs.*—The disarticulation of the hip even by the raquet process, with preventative ligature of the vessels, is more serious than an intertrochanteric amputation.

A thigh stump ought to be at least 12 to 14 cm. in length below the great trochanter in order to permit of a successful artificial limb.

The amputation of the thigh in the upper region makes it difficult to provide a substitute because of the removal of the femur.

An amputation in the middle or lower region gives good results. The sciatic nerve must be cut above the flap.

The Gritti operation should not be practiced except in delayed amputation.

The disarticulation of the knee is effective as a preliminary operation.

Amputation in the plateau of the tibia gives good results, as it permits walking with the stump of the knee.

Amputation of the leg should be as low as possible: the posterior flap is preferable; the fibula should be cut about an inch above the tibia.

Excellent results may also be obtained by tibio-tarsal disarticulation with section of the malleoli, subastra-

galus disarticulation, Lisfranc, osteoplastic amputations, Syme, Pirogoff.

The Chopart operation may be practiced in secondary and delayed amputation.

Any resection of the bones of the foot which leaves a good plantar sole with normal axis of the leg should be preferred to amputation. (Further discussion at fourth conference, see p. 70.)

*Amputations of the upper limbs.*—In amputations at the shoulder it is well to preserve the head of the humerus.

Amputations of the arm should be as low as possible—10 cm. of bone are needed for a stump. The method may be either circular or with flaps.

In amputations of the forearm leave, whenever possible, 10 cm. of bone below the elbow for leverage. The movements of pronation and supination should be maintained.

On the hand only primary rectifications should be made, unless more complete operations are necessary, because of the service value of every segment preserved.

Treatment of joints above the place of amputation, as well as the exercise of the muscles, should be continued during the entire period of healing.

The artificial limb should be applied as soon as possible. The use of a temporary apparatus is often called for, especially in the case of the lower limbs.

The "cinematic" method may afford indications in the case of the arm and forearm.

## VIII. Artificial Limbs.

1. Artificial members should be functional and esthetic; that is, they should, if possible, restore the function and the form of the amputated part. They should be supplemented by a functional and professional reeducation.

2. Substitution ought to be as early as possible. In the case of lower limbs it should be made as soon as the condition of the wound permits. The use of crutches should be limited as far as possible. To enable the patient to walk before his wound is healed, temporary supports may be devised, the best being those contrived by the surgeon himself.

3. For the upper members the substitutes are made of leather with metal splints. They include:

(*a*) An assistance arm, a kind of simple, cheap substitute which serves a laborer fairly well as soon as his stump is healed.

(*b*) An arm for appearance and work.—This is a more complicated and esthetic contrivance than the assistance arm, but stronger and more useful. Such limbs are made up of (1) some means of suspension upon the shoulder and breast (a leather plate, a corset,

a vest supplied with straps) to which is added a leather sleeve for amputations of the forearm; (2) a sheath affixed to the stump to which the professional utensils are attached, and, for the completed apparatus, the esthetic hand with an automatic thumb.

4. For the lower limbs the apparatus varies accordingly as the patient's stump is or is not thoroughly evolved. (This process sometimes requires 12 months.)

(*a*) For stumps in process of evolution the apparatus employed is of leather, with metal splints, permitting adjustment to the changing stump. Such limbs are made up of (1) some means of fixation and suspension (body, belt, straps for amputations of the thigh, and a thigh band for amputations of the leg; (2) a sheath affixed to the stump, into which the weight of the body is thrown in walking; its upper edge should be modeled with great care at the points of bearing and well padded. This sheath may later be replaced by either a wooden stump or an esthetic foot and leg, articulated at the knee freely or with a lock.

In the Belgian Army these intermediary appliances are not used, the first temporary apparatus serving until the stump is fully developed.

(*b*) For stumps completely developed the appliances of reinforced leather ought to be replaced by an apparatus the sheath of which is made of some rigid mate-

rial (wood is used by Americans, wooden shavings glued and compressed are used by the Belgians, fibrous leather, metal plates, etc.). These appliances are much lighter, simpler, and more durable than those made of reinforced leather. Their interior surface must be exactly modeled to fit the stump and the points of support for the body when the appliance is in place. They should reproduce the form of the amputated member and consequently reestablish the normal bearing of the patient. They should also be provided with articulations which make possible movements approximating the normal.

## IX. Fractures.

### A. CHOICE OF APPARATUS.

1. In the treatment of complete fracture by war projectiles, fixation takes precedence over reduction.

2. Immobilization is necessary under three conditions, requiring different methods of procedure:

(*a*) Temporary immobilization at the rescue station.

(*b*) Permanent immobilization at the surgical center.

(*c*) Immobilization during transportation.

Temporary immobilization ought to be as nearly as possible like the permanent immobilization, and this latter should be of a nature to permit the transportation of the patient.

Any appliance for fixation should permit the use of mechanical extension, easy access to the wound, and the transportation of the patient.

### FRACTURES OF THE ARM.

(*a*) *Temporary immobilization at the rescue station.*—Thomas splints and crutches give excellent results. Their use should be more general in the armies.

(*b*) *Permanent immobilization.*—The foregoing appliances, frames, and adjustable brackets permitting the abduction of the member and extension crutches are useful in permanent immobilization.

### FRACTURE OF THE FOREARM.

(*a*) *Temporary immobilization at the rescue station.*—A grooved metal splint with an elbow at right angles, or a simple wooden splint, are sufficient.

(*c*) *Permanent immobilization.*—The forearm should be immobilized with the patient in a supine position, and the appliance should allow as far as possible the application of mechanical extension and variation in the degree of elbow flexion.

Appliances of the Thomas and Sinclair type, plaster with metal splints, and the Vamelvede splint meet the requirements.

FRACTURES OF THE THIGH.

(*a*) *Temporary immobilization at the rescue station.*—The best splint appliance is that of the Thomas type. It is well to add to the splint a foot rest to prevent the heel from being drawn forward during removal on a stretcher.

(*b*) *Permanent immobilization.*—The appliance chosen should permit extension, abduction, and flexion of the member (splints of the Thomas type, suspensory mechanism of the Anglo-American type, the Delbet and d'Alquier appliances). The Delbet appliance permits very early walking.

The number, the seat, and the extent of lesions upon the lower limbs and the intolerance of all appliances may warrant the use of Finochietto's stirrup. The addition of a splint of the Thomas type to this stirrup makes possible the transportation of the patient while extension is maintained.

FRACTURES OF THE LEG.

(*a*) *Temporary immobilization at the rescue station.*—Splints of the Thomas type and grooved metal splints meet all requirements.

(*b*) *Permanent immobilization.*—The appliance chosen should permit mechanical extension.

Extensible appliances of plaster with metal splints and adjustable posterior splint, all the extensory ap-

pliances with suspension, and the Thomas splint meet this requirement.

It is well to begin walking as early as possible. The best apparatus for this is Delbet's, in which a lateral plastered splint is replaced by a metal splint, bridged if the position of the wound requires it.

The Finochietto stirrup, alone or with a splint of the Thomas type, meets the same requirements in fractures of the leg as in those of the thigh.

FRACTURES OF THE WRIST.

(*a*) *Temporary immobilization at the rescue station.*—A grooved metal splint or a wooden splint meets all requirements.

(*b*) *Permanent immobilization.*—The Robert Jones splint is excellent.

FRACTURES OF THE ANKLE.

(*a*) *Temporary immobilization at the rescue station.*—A grooved metal splint is sufficient.

(*b*) *Permanent immobilization.*—Plaster appliances with bridges immobilize perfectly.

The same apparatus may be used for walking.

The metal appliance of Robert Jones will render the same services.

If in the transportation of the wounded the so-called permanent apparatus has to be removed a plaster appliance may be substituted.

### B. SURGICAL TREATMENT OF FRACTURES.

I. *At the rescue station* the treatment of fractures consists in—

(*a*) The bandaging of the wound.

(*b*) Immobilization.

(*c*) The immediate treatment of complications (hemorrhages and shock).

Immobilization may be obtained by temporary appliances. (See "Choice of apparatus.")

II. *At the first surgical center* all fractures should be examined, radiographed, and operated if necessary.

1. Destroyed parts and gangrenous segments should be amputated as nearly as possible in the region of the fracture.

2. A seton ball wound, with small orifices at the point of entrance and exit, and without intermediary swelling lesions of the large blood vessels, may be immobilized a Thomas appliance, in a grooved splint, or in aster. The wound should be treated aseptically. The atient should be carefully observed for at least a week. nd if marked local or general infection takes place the fracture should be operated.

3. All other fractures should be operated.

(*a*) *Treatment of the wound.*—The wound should be opened wide enough to permit a deep exploration of the entire region of the fracture. Soft parts should be ex-

cised and foreign bodies removed (according to the general recommendations for operating wounds).

(*b*) *Treatment of the bone.*—The cutting away of bone splinters is the first essential. First remove the free splinters, those that are only slightly attached to the muscular parts. All ablation should be subperiosteal and thorough. Bony protrusions that are irregular and that endanger the nerves and blood vessels should be removed with a gouge forceps.

The cleansing solution is left to the choice of the surgeon; ether and Dakin's solution are most popular.

The wound should then be treated by primary or secondary suture.

At present primary suture of the soft parts is exceptional and is practiced only under the following conditions: The presence of an experienced surgeon; adequate supplies and a period of military calm; wounds of not more than eight hours' standing; slight muscular and bony destruction, even after the excision of all the contused tissues; easy closing of the wound; and the possibility of watching the patient until the wound is completely healed. The most favorable regions are the face, the cranium, parts over flat bones, the patella, the hands, and the feet.

At the first sign of complication the wound should be opened and cleaned.

Secondary suture should be preceded by progressive sterilization.

The Carrel and Morison methods give good results.

III. *Cases of fracture ought not to be moved during infection.*

IV. *Reduction, position, and extension* of a member may be controlled by means of radiographs.

V. Some *fractures that resist reduction* may be best subjected to internal fixation. This treatment ought to be applied so far as possible after the thorough sterilization of the wound.

VI. *Uniformity of treatment* for serious fractures at the various sanitary stations tends to give better results.

VII. *Exercise* of the joints, muscles, and tendons of the fractured member is requisite through the entire period of treatment and should begin as early as possible.

X. *Treatment* of wounds of the joints.

1. At the rescue station wounds of the joints should be immobilized with great care in some suitable appliance.

2. Except in the case of ball wounds with punctiform orifices and without fracture, which may safely wait, every wound of the joints ought to be operated upon within 6 or 8 hours at some surgical formation near the front.

With the English surgeons indication for operation consists in the extent of the wound, laceration of the articular tissues, the presence of the projectile, and, especially, fracture.

3. A radiological examination is indispensable in all cases.

4. Large aseptic arthrotomy with excision of the tract, wide exploration of the joint, careful ablation of foreign matter and bone splinters, and rectification and curetting of the bone, may be followed by complete or almost complete reunion without drainage. A compressive bandage should be applied.

5. Typical or atypical resection should be practiced only for considerable damage to the bones; at the knee it should be primary, whereas at the elbow and shoulder secondary resection is preferable.

6. In case of serious arthritis with suppuration, first try large arthrotomy with complete immobilization and progressive disinfection of the wound. In case this treatment fails, resection followed at once by separation of the bony surfaces should be practiced. In very serious cases immediate resection is admissible.

7. If there is considerable damage of the articulating bones, together with epiphysial fracture of both segments, accompanied by serious infection, recourse must be had to amputation.

After a simple operation M. Gosset prefers a padded compressive bandage without immobilization.

MM. Depage and Tuffier insist that the limb should be completely immobilized for 8 or 10 days, after which time mobilization may begin.

MM. Willems and Derache believe that mobilization should begin much earlier.

## X. Wounds of the Blood Vessels.

A projectile in the neighborhood of a blood vessel may cause either contusion or a wound (incomplete section, complete section, or perforation).

Contusion is evidenced by thrombosis, which is usually unrecognizable until embolism or a secondary hemorrhage takes place.

Wounds of the blood vessels betray themselves generally by an immediate external hemorrhage in the case of large wounds or by the presence of diffuse hematoma in the case of narrow tracts.

After patients have been removed to the hospital of the district arterial or arterio-venous traumatic aneurysms resulting from a vascular wound which have escaped attention may be detected.

*Treatment.*—1. Contusion should be treated by ligature below and above the thrombosis. Arteriotomy followed by suture must be rejected.

2. Vascular wounds with external hemorrhage call for treatment which begins at the rescue station and is completed at the hospital.

(*a*) At the rescue station the treatment should be varied according to the amount of the hemorrhage. If the flow is slight, compression above the wound or in the wound itself may be produced by bandages. If the hemorrhage is serious, a tourniquet must be applied. All cases with tourniquets should be clearly designated and removed immediately to a surgical station for operation. Our English colleagues, because of the peculiar conditions attending their removal of the wounded, employ forcipressure and ligature instead of the tourniquet.

(*b*) At the surgical station, as a rule, the injured vessel should be laid open and ligatures applied to the healthy parts of the two ends. Vascular suture, whether lateral or circular, is the ideal operation if conditions are favorable (that is, when the vascular lesions are limited and easily accessible and the wounds aseptic and capable of being completely closed).

3. Secondary arterial hemorrhages should be treated by ligature of the two ends of the injured vessel, or, if this treatment is impossible, by the application of fixed forceps or by ligature at a distance; amputation is the last resort.

4. In vascular lesions with diffuse hematoma preventive hemastasis must first be effected (tourniquet, compression of the artery after exposure from above); then a wide opening of the hematoma; finally ligatures should be applied to the ends of the injured vessel, or, as is seldom possible, suture may be effected. In case the lesion is so situated as to endanger the reestablishment of the circulation (popliteal, common femoral, axillary) the temporary introduction of a parffin tube bound to the two ends of the vessel diminishes the danger of gangrene.

Diffuse hematoma is often complicated with gangrene. Ligature of the vein at the same time as ligature of the artery instead of increasing the risk of gangrene, as one might suppose, actually diminishes it. Facts tend to prove that in the case of lesion of the arteries simultaneous ligature of the uninjured vein is desirable.

5. In traumatic aneurysm, immediately after hemostasis has been effected, the sac should be opened; in this way access is obtained to the primary vascular lesion, and ligature may be applied close to the lesion, thus avoiding injury or exclusion of the collateral branches in the near neighborhood.

(*a*) In arterial aneurysm the ligature of the two ends should be followed by the complete removal of the sac, or the partial removal of it in case complete removal is

dangerous. Suture of the arterial orifice is here again the ideal operation if it can be accomplished.

(*b*) In arteriovenous aneurysm more common and less dangerous than arterial aneurysm and less frequently complicated with gangrene, the ideal operation is the removal of the sac and the reestablishment of arterial and venous continuity by means of suture. In practice ligature of the four ends followed by the total or partial removal of the pocket is the usual procedure.

## XI. Wounds of the Nerves.

1. In surgical formations at the front it is necessary to search with utmost care for lesions of the peripheral nerves by clinical examinations and examinations made directly in the wound at the time of the first treatment.

2. Whenever a peripheral nerve trunk is found to be severed, primitive suture of the nerve should be effected if the conditions of the wound permit, and mention of this suture should be made on a special bulletin accompanying the patient.

3. If the nerve could not be sutured at the time of the first treatment, or if it was overlooked, the necessary operation may be performed at the time of the union by second intention.

4. This operation, whether primary or secondary, may of itself suffice for the restoration of the nerve function.

In any case it prepares the nerve trunk in the best way possible for subsequent treatment if such proves necessary.

5. Later on all functional defects resulting from nerve lesions may be subjected to operations in accordance with the advice of a neurologist.

6. During the whole course of the treatment a favorable position of the segments of the member should be maintained, and the play of the joints and nutrition of the muscles carefully attended to.

7. Operations upon the nerves, whatever their character (liberation or suture), demand perfect asepsis, much attention to detail, and extreme gentleness in all action upon the nerve itself.

8. The suture should be made upon refreshed nerve extremities extending on to the healthy tissue; a lower end of normal appearance and freed from all fibrous tissue which might constitute a hindrance to regeneration should be utilized.

9. Contact between two nerve ends appears necessary to regeneration; nevertheless suture at a distance, and splitting of the lower end may be tried when other treatment is impossible.

10. So far graft has produced no definite results.

11. Instead of nerve suture, recourse may be had to tendon transplantation: (1) When suture of the nerve

is impossible; (2) when the functional result, in spite of the operation upon the nerve trunk, is unsatisfactory.

## XII. Wounds of the Spinal Cord.

1. At the rescue station, practice the usual bandaging and deal with the shock phenomena which frequently attend wounds of the spinal cord.

2. At the surgical formation: (*a*) If there is a ball wound with a punctiform orifice, bandage and observe; (*b*) if there is a shell wound with a large entrance orifice, treat the wound as usual without paying attention to the medullar lesion.

3. Remove the patient at the earliest opportunity in a Bonnet grooved splint.

4. From a therapeutic point of view there are two altogether distinct classes of wounds of the cord—(*a*) complete section, against which surgery is powerless; (*b*) compression by a projectile, by splinters, by the displacement of bones, or by meningeal hemorrhage.

Intolerable pain may be a decisive indication for treatment.

5. When is it best to operate?

In most cases primary treatment is out of the question. In the Italian Army, however, operation as early as possible has been decided upon for bone compression and the entrance of projectiles into the spinal cavity,

so as to remove the projectiles, bits of clothing, clots, and splinters, and thus free the cord and the spinal veins. The mortality resulting from these primary operations is very high. In order to reduce as much as possible the traumatism of the operation and to conserve the spinal column, *unilateral* laminectomy has been found preferable in the Italian Army.

6. The secondary operation should take place after the healing of the wound.

With a view to remote prognosis an absolute distinction should be drawn between lesions at the level of the cord itself and those on the level of the cauda equina.

## XIII. Cerebral Wounds.

1. At the rescue station cerebral wounds should be covered with a simple aseptic dressing.

2. If there is any considerable loss of tissue or serious complications, cases of cranial and cerebral wounds should not be transported for any great distance.

If the lesion is not so serious and if there is no grave menace from complications the patient may be removed to a hospital center, provided with a special service of surgeon and neurologist, where he may remain for a considerable time.

Operation should be early.

3. A case of cerebral wound ought not to be transported within three weeks after trephining for cranio-cerebral lesion.

4. The cranium should be carefully examined by X-ray and the projectiles and bony fragments exactly noted.

5. Indications for trephining are still under discussion in cases in which the fracture of the cranium is not evident, and when there is no cerebral symptom.

6. Local anesthesia is preferred for the operation. The sitting posture tends to diminish hemorrhage, and is easily maintained in secondary or delayed operations.

7. The cleaning of the wound is made by resection of the edges. Enlargement is practiced according to the seat, the direction, and the form of the lesions of the bone.

8. Bone should be removed to just beyond the limit of cerebral contusion. This is preferably done by means of gouge forceps, exceptionally with trephine, but never with chisel and mallet.

9. If the dura mater is intact it should not be disturbed, and in favorable cases the wound may be closed by first intention. If it is torn, its edges should be rectified and the opening increased to the limits of the cerebral lesions.

10. Clots, diffluent cerebral matter and foreign substances on the surface should be removed by ablatior

with a warm saline solution; deep splinters and easily accessible projectiles should be removed with the greatest precaution.

11. Small projectiles that are deeply imbedded and difficult of access, larger projectiles at the base of the cranium or in the ventricles, and those in the hemisphere opposite to the one with the lesion, should not be disturbed.

12. In bipolar wounds each opening should be treated separately, and the deep-seated part of the tract should be left undisturbed.

13. No drain or gauze should be placed in the cerebral substance. A cranio-cerebral wound may be treated by primary or secondary suture after sterilization. Research work is still desirable to determine which of these two methods is the more effective means of avoiding immediate, secondary, or late infection.

14. After the operation the patient should be given a half-sitting posture.

15. Early cerebral hernia without deep infection should be treated by enlarging the bone breach.

16. Small scars with large loss of bone, and those which give rise to cerebral troubles, should be treated by cranioplasty.

17. Complications should be treated, according to their origin (cerebral abcess, foreign matter, adherent

scars), by suitable operations, to be determined by a neurologist and surgeon in consultation.

## XIV. Wounds Penetrating the Chest.

1. Wounds penetrating the chest result in a mortality estimated at 20 per cent in the sanitary formations of the Army zone.

2. Early death is the rule because of asphyxiation and hemorrhage. Shock plays a large part in the early or immediate death.

3. Late mortality usually results from pleuro-pulmonary infection.

4. Pathological anatomy establishes that the pulmonary lesions are the same as those of all war wounds. The mechanical disturbances are the same, the infection is the same, except that pulmonary tissue resists infection better than other tissues, but the infection of the pleura either by the external air or by the pulmonary wound may seriously complicate the case.

5. Two points in the treatment are of utmost importance: Immediate attention and complete immobilization of the patient.

When the patient is suffering from shock, general treatment for shock should be undertaken, and the patient should be given a reclining posture, with the head lowered.

Medical treatment is sufficient for the healing of many chest wounds which present no complication.

Surgical treatment should be employed for parietal lesions and for immediate or late complications.

In all cases complete surgical treatment of thoracic lesions (wounds of the soft parts, fractures of the ribs, etc.) is absolutely necessary, as in all war wounds.

### A. IMMEDIATE COMPLICATIONS.

(*a*) *Opening of the thorax.*—Closing is necessary either by plugging or by direct suture of the wall.

(*b*) *Hemorrhage.*—With open thorax: Direct hemostasis of the lung either by plugging or by hemostatic suture. With closed thorax: If it is certain that shock is not the primary cause, and if the blood pressure drops in spite of treatment, and if there are symptoms due only to hemorrhage, the ideal operation is thoracotomy with direct hemostasis of the lung. Indication for operation in cases of closed thorax is very rare. Such treatment requires competence and equipment of the highest order.

(*c*) *Hemothorax.*—If hemothorax is discovered, puncture to relieve mechanical compression is permissible. It is well during or after the drawing of the blood to inject air or oxygen into the pleura, in order to prevent hemostatic collapse of the lung. Febrile hemothorax calls for exploration by repeated punctures for the bacteriological examination of the liquid.

B. LATE COMPLICATIONS.

(*a*) *Persistent aseptic hemothorax.*—This variety of hemothorax should be treated by repeated puncture for evacuation, to allow of pulmonary expansion. The introduction of a certain amount of oxygen into the pleura during or after these punctures is often useful.

(*b*) *Infected hemothorax.*—When infection of the pleural fluid has been established by bacteriological examinations thoracotomy is definitely indicated.

(*c*) *Purulent pleurisy.*—This may be treated in the same way as infected hemothorax. When drainage is deemed necessary it should always be effected at the lowest point (the posterior base of the thorax).

6. Treatment of pleural suppuration by the method of progressive sterilization.

In recent or old cases of pleural suppuration there may be practiced progressive sterilization and secondary suture of the thoracic wall. There is no reason to fear a suture of the thoracic wall over an empty cavity. It is the best treatment to obtain rapid expansion of the lung and the disappearance of the pleural cavity (Depage).

7. In urgent cases it is well to proceed at once to the extraction of intra-pulmonary projectiles when conditions are favorable.

8. Whatever the circumstances, prophylactic therapeutics of the pleuro-pulmonary infection by means of

direct surgical treatment of the lung wound (extraction of all foreign bodies, suture of the wound with or without excision) seems the logical procedure. This question deserves careful investigation.

9. Blood effusion in the pericardium is governed by the same therapeutic principles as hemothorax.

## XV. Abdominal Wounds.

1. On general principles, all recent wounds of the abdomen should be operated, except when the lesion is without doubt limited to the liver or the kidney and when there is no symptom of serious hemorrhage.

2. The operation should be performed as early as possible, except when the patient is suffering from shock. When there is doubt as to the relative seriousness of the shock and that of the hemorrhage it is better to operate. Do not make a practice of laparotomy later than 36 hours.

3. Centers should be established as near to the lines as possible, provided with all surgical appliances which are now recognized as necessary, where all cases of abdominal wounds may be taken for operation by competent surgeons.

## THIRD SESSION, NOVEMBER, 1917.

### I. Disinfection of Wounds.

Since our last session the disinfection of wounds has passed more and more from the realm of chemical treatment to that of mechanical treatment by surgical means. Primary suture of wounds has taken precedence over secondary suture as a general method of treatment.

Primary suture, which we had formerly regarded as exceptional, has now become the method of preference. It has been practiced as immediate primary and delayed primary (or early secondary).

Immediate primary suture may, it appears, be safely practiced far beyond the time limits we had fixed for light wounds.

Delayed primary suture consists in mechanical sterlization of the wound and in the complete surgical closing of the wound at a later period of from one to four days after the cleansing operation and after bacteriological verification.

Among the organisms the presence of which is likely to bring about serious complications after the suture

those of first importance are the streptococcus and anaerobic species, especially the spore-bearing variety.[1]

## II. The Value of Bacteriology in War Surgery.

Laboratories annexed to the surgical centers have rendered the greatest service in the matter of surgical technique. Every effort should be made to perfect them as regards both the personnel and the equipment.

At present it is impossible to give any concise bacteriological formula to serve as an indication for the closing of wounds.

There is need occasionally to call together the bacteriologists from the surgical centers, so that they may discuss the results of their methods and give each other the benefit of their various experiences.

## III. Gas Gangrene: Treatment.

Because of acidosis, in some cases of gas gangrene an alkaline treatment[2] has been instituted. This may be for the purpose of rendering a later operation possible in the case of patients whose condition does not permit of a primary operation; or it may be employed for disintoxication. Encouraging results have been obtained

[1] MM. Castellani and Sacquépée call attention also to the danger from certain other varieties, especially of the Proteus group.

[2] Intravenous injection of 500 gm. of the following solution, sterilized in the autoclave: Bicarbonate of soda, 50 gm.; distilled water, to 1,000.

by this treatment. Further attempts should be made in this direction.

Some cases have been treated by various specific sera—anti-Perfringens,[1] anti-Vibrion septique,[2] anti-Bellonensis.[3]

These three sera have produced no unfavorable results.

The anti-Perfringens serum, which has been used preventively in several cases, seems to have given encouraging results. As a cure it has been sufficiently successful to warrant further attempts.

The use of anti-Vibrion septique and anti-Bellonensis has given very marked results, by way of cure as well as of prevention, even when administered in very advanced stages of toxic forms of the disease. These results make further tests desirable.

## IV. Shock.

Since our last session the therapeutics of shock have been modified (see p. 16).

Three causal agents of the state of shock are to be distinguished—hemorrhage, infection or subacute intoxication, and genuine shock.

[1] Serum prepared at the Pasteur Institute by M. Veillon.
[2] Serum prepared at the Pasteur Institute by MM. Nicelle and Jouan.
[3] Serum prepared at the laboratory of the IVth Army (France) by M. Sacquépée.

It is very difficult to distinguish these three conditions. The number of red corpuscles in the veinous blood, if the count is made during the first hour after the wound, taking into consideration the time that has elapsed, makes it possible to detect any serious hemorrhage.

So far this method has been applicable only in the case of limb wounds. In these, however, any marked reduction in the number of red corpuscles is an indication of serious hemorrhage.[1]

Under these circumstances transfusion has proved successful.

In genuine shock, warming of the patient is the essential in any treatment. All beds intended for shock patients should be heating beds.

English surgeons in treating shock make use of intravenous injections of a 4 per cent bicarbonate of soda solution in doses of 500 c. c.

Other saline solutions have so far given no favorable results.

## V. Artificial Limbs.

The experience of the past months has confirmed the superiority of the appliances of rigid material, of which the so-called American appliance is the type, in

[1] Less than 4,500,000 during the first 3 hours; less than 4,000,000 during the first 8 hours; less than 3,500,000 during the first 12 hours.

preference to all reinforced leather appliances. They are to be employed after the stump has completed its development.

A temporary appliance, employed as soon as the amputation wound permits, hastens considerably the development of the stump.

## VI. Surgical Treatment of War Fractures.

The surgical treatment of war fractures has made great progress.

1. *Organization.*—(*a*) Distribution from the rescue station of good immobilization appliances (Thomas splint) and the immediate removal of cases from the rescue stations to the surgical center.

(*b*) The increase in the number of specialized surgical centers.

(*c*) Perfect uniformity among the different squads, thus permitting absolute unity of treatment at the different stages.

2. *Technique of operation.*—Primary reunion of diaphysary fractures has become much more common.

About 51 per cent of diaphysary fractures by shell fragments are treated primarily. In order of frequence these are for wounds of the forearm, arm, leg, and thigh (of the last only 20 to 25 per cent are treated primarily).

The following principles seem established: Before all, transform an open war fracture into a closed one, whether by primary suture practiced at once or after some delay permitting of bacteriological control.

Secondary suture may be performed after chemical disinfection combined with bacteriological control.

3. *Treatment of diaphyseal fractures of the thigh.*— Generally speaking, ultimate results of the treatment of thigh fractures have been mediocre.

This fact is due to the extent of such lesions, to the insufficiency of reduction and fixation, and especially to the infection of the region of the fracture.

Ultimate results from fractures of the upper and lower thirds of the femur are most defective.

Late complications most frequently noted are: (1) Infections in the form of chronic osteomyelitis; (2) difformity due to insufficient reduction (shortening, rotation, angulation); (3) rarely noted defects in consolidation or functional weakness of joints, muscles, or nerves.

Among the deformities shortening is the most frequent and the only one which can not always be avoided, for it may result from actual loss of bone substance.

Rotation and angulation are generally due to insufficient surgical care.

Primary sterilization is the first condition to be realized. Defective results are usually due, directly or indi-

rectly, to incomplete sterilization. The delay and difficulty attending the treatment of prolonged infections render fixation much more difficult.

Primary suture of the wound and secondary suture after scar formation, practiced for the purpose of transforming an open fracture into a closed one, may exercise a chief influence upon the ultimate results.

The very frequent stiffness of the knee and that of the hip and foot, whether separate or associated, may be avoided by early exercise.

Muscular adhesion to the callus is the cause of various functional disturbances which may require surgical liberation.

Trophic affections (muscular atrophy, edema, vasomotary disturbances) play a very important rôle and ought always to be the object of early and persistent attention.

Very pronounced irregularities, with or without osteomyelitis, are amenable to osteotomy. In cases complicated with osteomyelitis the resection of the callus is indicated.

4. *Wounds of the joints.*—At the present time complete closing of joint wounds is universally approved. Such good results have been obtained that now, when the excision of contused tissue has involved serious loss of subcutaneous substance, thus rendering direct closing

impossible, this loss may be made good by cutaneous autoplasty. Bony cavities in some cases may be filled with muscular flaps.

The aseptic progress of bone wounds of the joints when they have been operated upon within 10 or 12 hours after the injury makes possible a maximum of surgical conservation.

Epiphyseal fractures or epiphyso-metaphyseal fragmentation (trabecular fractures, incomplete perforations, etc.) are amenable at present to cleansing and curetting, followed by primary closing of the joint.

Epiphyseal and partial or T-shaped epiphyso-metaphyseal fractures are amenable, according to the nature of the case, to arthrotomy with reduction, or to arthrotomy with a conservative sequestrectomy (partial atypical resection), followed by primary suture.

Primary resection is now only occasionally indicated:

(*a*) In case of extensively comminuted fractures of the joints: Even in these cases the indications are more urgent when the hip or shoulder is involved than when it is a question of the knee, the elbow, or the ankle.

(*b*) In questionable cases the practice of primary resection with a view to obtaining a better functional result should give way to conservative methods (arthrotomy with conservative sequestrectomy and partial atypical resection).

Defective functional results are amenable to late orthopedic resection, which is usually more effective than primary resection.

Amputation is indicated in cases of injury involving the destruction of the principal arterial trunk.

Immediate active exercise appears to be the indispensable complement of surgical treatment and has given much better result than immobilization (Willems).

Resection is still desirable in cases of infection of joint fractures.

5. *Treatment of chronic osteomyelitis.*—Bone infection is brought about in the same way as infection in other types of war wounds.

It is promoted in two ways—(*a*) Directly through medullar and compact tissue; (*b*) indirectly along fissures.

Penetration through the bony substance is generally slow and limited in extent.

Among the first bacteria to invade are to be noted streptococci, staphylococci, enterococci, and, less frequently. the anaerobes.

In the flora of subacute or chronic bone suppuration the following organisms are most frequently found: Streptococci, staphylococci, enterococci, and pneumobacilli.

The treatment for chronic osteomyelitis is chiefly preventive. It consists simply in the proper treatment of the fracture.

(Reference is made to the subject of Fractures as presented in the conclusions adopted at this and the previous session of the Interallied Surgical Conference. For the latter, see p. 26).

The treatment of established osteomyelitis is at present purely surgical. It should be practiced as early as possible and should consist principally in (*a*) generous opening of the region, (*b*) minute search for and removal of all sequestra and foreign bodies, and (*c*) the leveling of all cavities.

After this procedure there are two possible courses open—(*a*) either the immediate closing of the wound with autoplasty of the gap in the bone by means of flaps, or (*b*) chemical sterilization of the wound, followed by secondary autoplasty and suture. This last method is the one usually adopted.

## VII. Chest Wounds.

Surgical treatment of chest wounds tends clearly toward active surgery—

(*a*) In case of dangerous hemorrhage, an open thorax is always operated.

(*b*) Primary extraction of intrapulmonary projectiles is more frequently practiced.

Treatment of the parietal wound consists in excision and removal of all foreign matter, whether bone or metal, lodged in the lung, cleansing of the wound, and immediate primary closing of the thorax. Good results thus obtained clearly justify this method of surgery.

(*c*) Infected hemothorax is treated by very early drainage and progressive disinfection and secondary closing of the thorax.

(*d*) Chronic purulent pleurisy is amenable to progressive sterilization, accompanied, if necessary, by the opening of the pleuropulmonary casing by several incisions.

## VIII. Wounds of the Abdomen and Thorax.

In wounds of the abdomen and thorax, the wound of the diaphragm constitutes the specific factor of the lesion; the wounds of the organs of the abdomen and thorax present no special anatomical interest.

Hernia of the abdominal organs is difficult to recognize clinically. Radioscopic examination reveals the displacement of the heart to the right, and so helps in diagnosis, so far as the left side is concerned.

Indications for operation are absolute except in the case of a very small projectile in the upper part of

the abdomen, especially at the right. The perforation of the diaphragm in itself necessitates suture.

Approach by way of the pleura affords especial advantage for exploration of the lesions and also for treating the pleural cavity or for suturing the diaphragm. It permits also the treatment of lesions in the abdominal organs, beneath the diaphragm, whether there is hernia or not.

A separate laparotomy may sometimes be necessary.

The opening of the thorax and abdomen by a single incision permits generous treatment of both chest and abdominal lesions.

## IX. Brain Wounds.

1. *Surgery.*—Brain wounds are disinfected mechanically by trephination, cleansing of the cerebral substance with warm water, and the extraction of easily accessible projectiles.

Bacteriological control, in this as in all wounds, will furnish indication for complete closing. In case foreign bodies may not be extracted, primary closing, whether immediate or delayed, ought to be practiced with extreme prudence.

Very great care must be exercised if grafts are attempted.

2. *Secondary and late complications in brain wounds.*—All documentary evidence available[1] indicates that although secondary complications in cerebral wounds are comparatively frequent, late infectious complications are much less common than was supposed.

Organic disturbances resulting from wounds of the brain (hemiplegia, monoplegia, aphasia, visual disorders, etc.) frequently improve. The treatment is properly neurological.

Late epileptic seizures of the Jacksonian variety may benefit by surgical treatment for the removal of the cause of pressure, of foreign bodies, and of splinters. It is useless to operate for one or two isolated seizures of Jacksonian epilepsy, for these may be due to an attack of encephalitis, which may be cured and which would not be affected by operation.

Epileptic seizures other than those brought on by foreign bodies or splinters do not call for fresh surgical treatment. Lumbar punctures, controlled by a manometer, may prove beneficial when there is hypertension of the cerebrospinal fluid.

[1] Out of 6,664 cases which had previously undergone trepaning at the hospitals of the neurological regional centers of France, there were recorded 676 cases of partial or general epileptic crises (or 10.14 per cent), 94 cases of late cerebral abscess (or 1.41 per cent), 32 cases of late meningitis (or 0.48 per cent), and 54 cases of late cerebral hernia (or 0.81 per cent). There were 83 deaths (or 1.24 per cent), but only 1 sudden death.

Late cerebral abscess, which should be carefully diagnosed and differentiated from nonpurulent encephalitis, may be operated after precise localization by the surgeon and neurologist. After an exploratory puncture, such as will not destroy the protective coverings, the abscess should be opened and its sterilization followed bacteriologically.

Late localized meningitis, encysted meningeal abscesses, should be operated.

The present treatment of generalized meningitis is usually of little avail. Repeated lumbar punctures appear to be the most rational.

Cerebral hernias with abscess should be operated and the abscess drained.

It seems best to abstain from lumbar punctures in the primary acute, febrile stage of certain cerebral hernias, thus avoiding the possible diffusion of a local infection. When the initial infectious phenomena have been reduced, lumbar punctures, for the purpose of relieving intracranial hypertension, may help to lessen the hernias.

Resection of hernias is permissible only in case of local necrosis or meningocele.

Foreign bodies in the brain, causing attacks of encephalitis, epileptic seizure, or abscesses, should be removed. It seems best not to disturb those that cause no apparent disorder.

Cranioplasty, judging from all available reports, appears desirable for esthetic reasons in case of frontal cavities. For curative purposes, however, it is justifiable only when the disorder is occasioned exclusively by the extent of the loss of bone substance. As a preventive measure, the danger of subsequent injury to the brain in the region of the gap may justify the operation. In any case, it must be carefully established that no counterindications exist, such as nervous disorders, chemical or cytological change in the cerebrospinal fluid, and papillar stasis.

Early therapeutic procedure, methodical disinfection, and primary sterilization of the intracerebral seat of injury are the best preventive methods against secondary or late infectious complications.

## X. Treatment of Nerve Wounds.

Treatment of nerves in war wounds has, up to the present, produced rather poor ultimate results.

In cases of partial section the percentage of good results is much higher than in those of complete section.

Poor results are due in large measure to late treatment.

Treatment ought never to be applied through a suppurating medium.

The three principal causes for failure in late treatment of the nerves are:

(*a*) Sclerosis of the peripheral end, increasing with delay.

(*b*) Too great separation of the ends.

(*c*) Intensity and duration of suppuration.

Retraction of the tendons, ankylosis of the joints, ischemic muscular sclerosis, all tend to lessen considerably the functional value of the result obtained by treatment. From the start a proper corrective attitude should be given to the joints.

Primary nerve suture, made possible by the present methods of wound disinfection, is likely to increase materially the frequency, the rapidity, and the extent of functional recovery.

Even in case of failure, primary suture fixes the nerve ends in an anatomical position which greatly facilitates a new operation.

Functional recovery is slow, requiring months and even years. This fact must be taken into account in judging injuries.

## FOURTH SESSION, MARCH, 1918.

### I. Wounds of Joints.

The Belgian representatives, MM. Soubbottitch and Gosset, proposed the following modifications of conclusions adopted at previous sessions:

1. Fresh joint wounds should first be excised and then sutured (primary suture) completely. Active movements of the involved joint should be begun immediately. The same rule holds good for intra-articular fractures, provided it does not involve the risk of displacement of fragments.

2. The best treatment for purulent arthritis consists in making a free incision (arthrotomy) followed by the institution of immediate active motion. This method is not painful, and it secures perfect drainage, avoids the risk of general sepsis and of muscular atrophy, and furnishes the assurance of unimpaired joint motion. (See Third Conference, p. 53.)

### II. Transfusion of Blood.

Transfusion of blood has been sufficiently tried out to warrant regarding it as the method of choice in the treatment of severe hemorrhage.

### INDICATIONS.

1. *During first hours after reception of wound.*—In dications are furnished by clinical study of the wounded supplemented by repeated blood pressure determina tions and counts of red and white blood cells.

In the advanced posts or wherever exigencies do no permit the making of blood-pressure readings and blood counts, the indication for transfusion must rest solely on clinical symptoms.

In case of circulatory failure due to severe infection (gas gangrene) transfusion has accomplished no good

In shock, the indications for transfusion are not sufficiently exact to be reliable.

2. *Later, during the course of treatment.*—Post hem orrhagic anemia with low red cell count is usually well tolerated; in such cases, transfusion is not indicated if the general condition of the patient is satisfactory.

### PRELIMINARY PRECAUTIONS.

1. It is desirable to examine and to classify donors

2. Cases of death following agglutination of the red blood cells of the donee occur, but they are rare and may be avoided to a certainty if preliminary agglutination tests are made.

In actual warfare transfusions may be made at the advanced stations and in the evacuation hospitals. In the latter hospitals all precautions should be taken. In

the advanced stations it is permissible to resort to transfusion, even if all preliminary tests can not be made.

3. One must not attempt a transfusion unless he has at his disposition a complete armamentarium in perfect working order and can command a strict asepsis.

### TECHNIQUE.

Whatever type of transfusion is used, one should be able to measure the quantity of blood transfused. Many successful attempts have been made to save blood for several days. This method has been of immense value at the front during periods of intense military activity.

The indirect method of transfusion (citrate method) and the direct methods (syringe or paraffined tube) have all furnished good results.

On general principle the transfusion should be done at the earliest possible moment after injury. One should not start the transfusion until hemorrhage has been checked. In thoracic and abdominal hemorrhage, or in case of severe injuries to the extremities, one transfuses before or during the operation, according to the condition of the patient.

## III. Trench Foot.

1. Trench foot is a pathological condition caused by damp and cold, complicated very often by secondary infection.

2. The condition develops in four stages, as follows:

(*a*) Stage of anesthesia.

(*b*) Stage of edema.

(*c*) Stage of blister formation.

(*d*) Stage of slough or gangrene.

Three clinical forms may be described:

(*a*) The mild type (85 to 90 per cent of cases), characterized by painful anesthesia, redness, and edema.

(*b*) The moderately severe type (13 to 14 per cent), characterized by bullae and limited sloughs.

(*c*) The severe type (1 per cent of cases), characterized by spreading gangrene and evidences of septicemia. This form is gravely mutilating and often fatal.

The amputation of one or more toes occasions slight inconvenience. The conservation of just one toe—in particular the first or fifth—leads often to inconvenience.

The disarticulation of the metatarsal bones with preservation of the corresponding toes leads, in general, to unfavorable results.

The preservation of the great toe and the corresponding metatarsal bone leads to an unsatisfactory result as a rule.

3. Trench foot, especially the graver forms, are often complicated with tetanus and gas gangrene. It is a disease of recurrences and exacerbations. It occurs almost exclusively in soldiers living in trenches, and par-

ticularly in soldiers living in certain trenches. Soldiers from warm countries, negroes in particular, are attacked more often than others. Youth, hyperidrosis, and constitutional taint are predisposing causes.

4. Blood stasis due to posture long maintained, compression of the leg, and compromise of the venous blood caused in particular by puttees combined with prolonged stay in damp, cold trenches constitute the primary causative factors.

5. Trench foot may be confused with frostbite and chilblain. Frostbite is characterized by massive gangrene of the foot in part or complete. Trench foot shows only limited gangrene in spots, usually on the dorsum of the foot, with a tendency to spread. Frost bite occurs with severe dry cold, whereas trench foot occurs in low damp regions, but is not prevalent in freezing weather. Chilblain is characterized from the outset by a severe itching as contrasted with the painful anesthesia of trench foot.

6. The treatment of trench foot is preventive and curative. Preventive treatment conscientiously maintained does away with the disease, or at least renders its incidence very low. It consists in—

(*a*) Maintaining life in the trenches so as to preserve the feet of the soldier in as dry and warm a state as possible.

(*b*) Individual measures, such as hygiene of the individual soldier's foot (cleanliness, frequent change of socks, and careful attention to protect against tight puttees). The Belgian soldiers, who do not wear puttees, rarely suffer from trench foot.

Curative treatment comprises:

(*a*) For the mild forms, a warm bath, with camphorated soap, every two or three days; daily warm packing of the feet in a moist borated camphor pack.

(*b*) For the more grave forms: If there are sloughs, persist in the above treatment. Do not attempt to excise the sloughs or to do anything more surgical to them than to scarify them, without drawing blood. Stimulate elimination and be on the watch-out for surgical complications. All operative procedures necessary to meet complications should be conservative and they should be instituted early. Amputation should be resorted to only when the hand of the surgeon is forced by serious systemic complications.

In all cases a prophylactic injection of antitetanic serum should be given early and repeated every eighth day until cicatrization is well under way.

## IV. Treatment of Wounds of the Pelvis, Particularly Those of the Bladder and Rectum.

*Uncomplicated wounds of the pelvis.*—These wounds are treated as are other wounds of the soft parts and

bones. Comminuted fractures of the iliac bone require wide trepanation.

The removal of projectiles and bone fragments often buried in the psoasiliacus muscle is particularly difficult, but must be done systematically.

*Wounds of the bladder.*—(*a*) Intraperitoneal wounds call for laparotomy and suture.

(*b*) Extraperitoneal wounds: Suprapubic wounds should be treated by primary suture of the bladder. In wounds of the lateral aspects of the bladder, surgically inaccessible, it is sufficient to treat surgically the wounds of entry and exit. This furnishes adequate drainage. Later, the insertion of a permanent catheter favors the closure of urinary fistulas.

Imperative primary cystotomy should be reserved for those cases of bladder injury with retention of urine or with progressive perivesical infiltration.

Grave hematuria, or the existence of an intra-vesical foreign body warrants immediate cystotomy.

Secondary infection of the bladder calls for cystotomy with drainage.

*Wounds of the rectum.*—(*a*) Intraperitoneal wounds are to be treated as all other wounds of the intestine, i. e., laporotomy and suture.

(*b*) Extraperitoneal wounds should be treated in the majority of cases by laying the wound open widely and

tamponading against the wound of the rectum itself. These patients should be kept constipated. In severe injuries with extensive denudation, the rectum should be freely exposed, if necessary, by a posterior rectotomy.

Primary colostomy is indicated in only exceptional instances.

*Wounds associated with injury to the bladder or rectum.*—The majority of these wounds heal rapidly after surgical treatment of the extravesical wound track.

Colostomy is indicated only for cases of extensive rectovesical communication.

Primary cystotomy is frequently useless. Permanent catheterization, ventral decubitus, and knee chest position for urination all favor the spontaneous closure of rectovesical fistulas.

## V. The Results of Conservative Operations for Projectile Wounds of the Foot.

The integrity of the plantar surface of the foot should be preserved when possible, and incisions should be made in this region only when absolutely necessary: when incisions are made on the plantar surface of the foot great care should be used to secure primary union. One may even be justified in doing a partial resection in order to avoid invading the sole of the foot.

Resection of the first and fifth toes with the corresponding metatarsal bones furnishes good results as a rule.

Resection of the second, third, and fourth metatarsals gives a slender foot that is very troublesome on the march or if the patient is obliged to stand.

In general, the removal of three metatarsals leads to grave static troubles.

A transmetatarsal amputation, with a good plantar flap, gives a very favorable result, whether it be done at the anterior or posterior part of the metatarsus.

After Lisfranc's disarticulation gait is easy and springy, provided the remaining portion of the foot is in good condition. The technique of this operation is simplified by leaving the bases of the metatarsal bones in the stump.

The prescaphoid-cuboid amputation gives good functional results.

All the operations on the anterior tarsus give good results, provided there are no complications referable to the cicatrix or to neighboring joints.

Chopart's amputation, provided it is done under favorable circumstances and carefully watched, may give good results. But the tendency to equinism which is likely to follow this type of amputation renders it

inferior to the Lisfranc and the Syme. Partial astragalocalcaneus resections tend to correct the equinism.

The Pirogoff and the Syme amputations permit of rapid, easy marching.

Operations on the posterior tarsus, however, are often followed by functional trouble. Total or subtotal astragalectomy gives good results, but not as good as in peace times. The poor results are referable to contiguous infections, stiff joints or tendons, and insufficient care in maintaining proper attitude after operation.

Complete or extensive calcanectomy, if it be not followed by bone regeneration, leads to much difficulty. Ankylosis (tibiotarsal or midtarsal) frequently occurs. Partial resections of the calcaneus may furnish good results provided careful attention is paid to after treatment.

Combined resection of calcaneus and astragalus is generally followed by a bad result.

*Atypical operations.*—Resection of the anterior tarsus (scaphoid and cuboid) are frequently followed by equinism with varus or valgus, and flattening of the arch. An orthopedic appliance often lessens the functional disturbance. The ablation of either one of these bones seems to have about the same serious consequences.

The results of atypical operations involving several bones of the anterior tarsus depend upon the preserva-

tion of the arch of the foot, the strength of the points of plantar support, and the function of the joints and tendons, as well as upon the site of the operation itself.

Vicious positions of the foot may be corrected or improved by tenotomy or by tendon transplantation. Certain instances will require operations on the bony structures (cuneiform resection, astragalectomy).

In résumé: Conservative operations on the metatarsus are excellent, but operations on the posterior tarsus, ablation of the calcaneus, or the combined resection of several bones often lead to functional troubles more serious than those which follow disarticulation or the Syme operation.

NOTE.—Prof. Depage stated that in suppuration of the tarsus, which persist in spite of astragalectomy, the foot should be held downward and inward by a bandage after free division of tendons and ligaments. In this position the focus may be disinfected more readily. The foot is restored to its normal position after 8 to 15 days.

## VI. INTERNAL SPLINTING IN WAR FRACTURES (PSEUDARTHROSES EXCEPTED).

In discussing internal splinting it is necessary to distinguish between the primary splinting (internal) of fractures and fixation done later during the period of infection.

### PRIMARY INTERNAL SPLINTING.

The possibility of performing either immediate or delayed primary suture on many wounds complicated by fractures rationalizes the principle of performing immediate bone fixation at the same time.

The indications for this procedure are uncommon, but may be stated as follows:

(*a*) Certain articular fractures in which internal splinting is the best method of reestablishing form and function.

(*b*) Certain irreducible diaphyseal fractures, or diaphyseal fractures in which reduction can not be maintained properly (in particular, supracondyloid fractures of the femur and forearm fractures).

(*c*) The presence of large displaced fragments.

As a rule modern appliances render it possible to secure good alignment and position without internal splinting.

Suture or plating of fractures is a difficult operation, which may lead to serious consequences and which should be performed by specialists.

In the British Army it is not the rule to resort to internal splinting, for the following reasons:

(*a*) Good results are secured by nonoperative procedures.

(*b*) Bad results that have so often attended the use of operative methods in the past.

*Internal splinting during the period of infection.*—This is a procedure accepted by certain authorities and condemned by others.

Advocates of the procedure claim that it lessens the infective process, rarely leads to osteomyelitis, and does not often lead to sequestrum formation.

On the whole, the method furnishes favorable results.

The indication for internal splinting during the period of infection is the impossibility of maintaining proper reduction in diaphysical fractures. But here again it may be said that modern apparatus, properly applied, renders it unnecessary, as a rule, to resort to internal splinting.

Temporary fixation with plate and screws suffices in the majority of cases where the method must be used.

## VII. Treatment of Pseudarthroses (nonunion).

1. The essential inevitable cause of pseudarthroses following war fractures is primary destruction of a part of the diaphysis. The other causes—infection, too extensive sequestrectomy, unskillful reductions—should not play much of a rôle.

One may avoid a certain number of pseudarthroses by careful asepsis and sterilization of the wound, by pru

dent sequestrectomy, by careful reduction, with good after care, and in certain cases by immediate internal splinting or suturing.[1]

2. One should never operate for the relief of pseudarthrosis until the wound is completely healed and all signs of inflammation have disappeared.

Remnants of inflammation should be carefully sought for by applying forced active and passive motions, active brisk massage, and the elastic tourniquet.[2]

3. It is necessary, from the therapeutic point of view, to distinguish two types:

(*a*) In simple pseudarthroses occurring in extremities with one bone, one may, after freshing the ends of the bone, apply a bone plate. The screws used in fixing the plate should be as far removed as possible from the bone ends.

---

[1] A. In cases of excision of the lower end of the femur or of the upper end of the tibia, or of both, the treatment will vary in accordance with the profession of the particular patient to be treated. In workmen one always tries to secure an ankylosis between femur and tibia, directly or by means of a bone graft. For those who follow a sedentary life a pseudarthrosis, regulated by an apparatus permitting flexion and extension, is desirable. An amputation of the thigh with artificial leg does not compare with either of the above procedures.

B. In case of extensive loss of substance of the lower end of the humerus, the elbow being intact, it is often desirable to obtain a pseudarthrosis between the shaft and lower fragment of the humerus, rotation taking place at the radio humeral articulation. Such a state of affairs is more satisfactory than is the one that follows resection of the elbow.

[2] An additional means of determining infection consists in the use of autogenous or stock vaccine.

Combinations of bone plates and bone grafts have furnished excellent results.

(*b*) Pseudarthrosis with loss of substance often requires bone or bone-periosteum grafts.

4. A perfect asepsis and the complete excision of fibrous tissue surrounding the fragments, and even of unhealthy portions of bone, is indispensable to success (Sir Arbuthnot Lane requested the addition of the above injunctions).

# INDEX.


| | Page. |
|---|---|
| Abdomen, wounds | 46 |
| Abdomino-thoracic wounds | 57 |
| Abscess, brain | 60 |
| Amputations | 19 |
| Amputation: | |
| Delayed | 20 |
| Indications | 15, 19 |
| Limbs, lower | 22, 71 |
| Limbs, upper | 23 |
| Primary | 20 |
| Aneurysm, traumatic | 36 |
| Artificial limbs | 24, 50 |
| Bladder, wounds | 68 |
| Blood transfusion | 63 |
| Blood vessels | 34 |
| Brain: | |
| Abscess | 6[illegible] |
| Meningitis | 6[illegible] |
| Wounds | 40, 58 |
| Cerebral hernia | 42, 60 |
| Chest, wounds | 43, 56 |
| Cranio-plasty | 42, 61 |
| Defects, skull | 6[illegible] |
| Empyema | 45 |
| Epilepsy, traumatic | 39 |
| Foot, wounds | 78 |

Fractures: Page.
Apparatus for 26
General treatment 30, 51
Operation for 32, 51
Of ankle 29
Of arm 27
Of forearm 27
Of leg 28
Of thigh 28, 52
Of wrist 29
Gangrene, gas 12, 48
Gas gangrene 12, 48
Hemorrhage:
Secondary 35
Treatment of 35
Hemothorax 44
Hernia, cerebral 60
Joints:
Pseudo-arthrosis
Wounds of 32, 53, 63
Laboratory methods 9
Locke's solution 18
Lumbar puncture 60
Meningitis 60
Nerves:
Operations 61
Wounds 37, 61
Nonunion, fractures 75
Osteomyelitis, chronic 55
Pelvis, wounds 68
Pericardium 46
Peripheral nerves 37, 61

| | Page |
|---|---|
| Pleurisy, purulent | 45 |
| Principles, general | 7 |
| Projectiles, extraction of | 11 |
| Pseudo-arthrosis | 75 |
| Rectum, wounds | 68 |
| Shock, traumatic | 16, 49 |
| Skull, defects | 61 |
| Solution, Locke's | 18 |
| Spinal-cord, wounds | 39 |
| Thoracico-abdominal wounds | 57 |
| Thorax, wounds | 43, 56 |
| Transfusion, blood | 63 |
| Trench foot | 65 |
| Wounds: | |
| Disinfection | 47 |
| Primary suture | 8, 47 |
| Secondary suture | 9, 47 |
| Abdomino-thoracic | 57 |
| Of abdomen | 46 |
| Of bladder | 68 |
| Of blood vessels | 34 |
| Of brain | 40, 56 |
| Of chest | 43, 56 |
| Of joints | 32, 63 |
| Of nerves | 37, 61 |
| Of pelvis | 68 |
| Of pericardium | 46 |
| Of rectum | 68 |
| Of spinal cord | 39 |
| Of thorax | 43, 56 |

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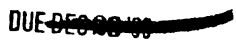

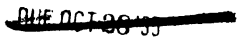

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